

What is claimed is:

1. A zoom lens comprising:

a plurality of lens groups which are moved with respect to each other to change a focal length of said zoom  
5 lens; and

a cam barrel having at least one cam groove formed on an inner peripheral surface thereof, wherein at least one of said plurality of lens groups is moved in a direction of an optical axis by rotation of said cam barrel in  
10 accordance with a contour of said cam groove;

wherein said cam barrel comprises: a first barrel having said cam groove on an inner peripheral surface thereof; and a second barrel which is fitted on a front part of an outer peripheral surface of said first barrel,  
15 said first barrel and second barrel being movable in said optical axis direction with a predetermined clearance therebetween in the optical axis direction while being rotatable together about said optical axis, so that an external force applied to said zoom lens from the outside  
20 of said zoom lens is transmitted to said first barrel via said second barrel.

2. The zoom lens according to claim 1, further comprising:

a moveable external barrel positioned around an  
25 outer periphery of said second barrel to be guided in the

optical axis direction without rotating about said optical axis;

an inward pin, fixed to said moveable external barrel, which projects radially inwards; and

5       a guide groove formed on an outer peripheral surface of said second barrel, said inward pin being engaged with said guide groove so that said moveable external barrel moves in said optical axis direction by rotation of said second barrel.

10       3. The zoom lens according to claim 2, wherein said inward pin comprises three inward pins positioned at an equi-angular distance about an axis of said moveable external barrel, and wherein said guide groove comprises three guide grooves positioned at an equi-angular distance about said axis of said moveable external barrel.

15       4. The zoom lens according to claim 2, wherein said zoom lens further comprises a stationary external barrel, said stationary external barrel being positioned around said moveable external barrel, and

20       wherein said stationary external barrel and said moveable external barrel cover said cam barrel so that said cam barrel is not exposed as an external portion of said zoom lens.

25       5. The zoom lens according to claim 1, further comprising:

a stop formed on said outer peripheral surface of  
said first barrel projecting radially outwards;

a linear guide barrel which guides said plurality  
of lens groups in said optical axis direction, and is  
5 positioned inside said first barrel to be rotatable about  
said optical axis direction relative to said first barrel  
and immovable in said optical axis direction relative to  
said first barrel; and

10 a flange ring fixed to the front end of said linear  
guide barrel,

wherein said second barrel is fitted on said outer  
peripheral surface of said first barrel between said  
flange ring and said stop to be movable in the optical axis  
direction by a predetermined amount of movement  
15 corresponding to said predetermined clearance.

6. The zoom lens according to claim 5, wherein said  
flange ring comprises an outward projection which projects  
radially outwards, and

wherein said moveable external barrel comprises a  
20 linear guide groove which extends parallel to said optical  
axis, said outward projection being engaged with said  
linear guide groove to guide said moveable external barrel  
in said optical axis direction without rotating about said  
optical axis.

25 7. The zoom lens according to claim 1, wherein said

first barrel comprises an annular raised portion formed on said outer peripheral surface of said first barrel in a vicinity of said front end of said first barrel to project radially outwards,

5 wherein a width of said annular raised portion in said optical axis direction is smaller than an axial length of said second barrel,

wherein an inner peripheral surface of said second barrel partly contacts with said annular raised portion,

10 and

wherein a slight gap is formed between said inner peripheral surface of said second barrel and said outer peripheral surface of said first barrel behind said annular raised portion with respect to the optical axis.

15 8. The zoom lens according to claim 7, further comprising:

a moveable external barrel positioned around an outer periphery of said second barrel to be guided in the optical axis direction without rotating about said optical 20 axis;

an inward pin, fixed to said moveable external barrel, which projects radially inwards; and

a guide groove formed on an outer peripheral surface of said second barrel, said inward pin being engaged with 25 said guide groove so that said moveable external barrel

moves in said optical axis direction by rotation of said second barrel,

wherein a position of said inward pin in said guide groove and a position where said inner peripheral surface 5 of said second barrel contacts said annular raised portion do not overlap in said optical axis direction when said zoom lens is in operation.

9. The zoom lens according to claim 1, further comprising:

10 a stationary barrel; and

a female helicoid formed on an inner peripheral surface of said stationary barrel,

wherein said first barrel of said cam barrel comprises a male helicoid formed on an outer peripheral 15 surface thereof to be in mesh with said female helicoid of said stationary barrel, and

wherein a front barrel portion of said first barrel, in front of said male helicoid with respect to the optical axis, has no helicoid thread formed on the outer peripheral 20 surface thereof, said second barrel being fitted on said front barrel portion.

10. The zoom lens according to claim 1, further comprising a focusing lens group positioned behind said plurality of lens groups, with respect to the optical axis, 25 wherein said zoom lens performs a focusing operation by

moving said focusing lens group in said optical axis direction to bring an object which is to be photographed into focus, and wherein said focusing lens group is driven independently of an axial position of each of said 5 plurality of lens groups.

11. The zoom lens according to claim 1, further comprising a shock absorber, positioned between said first barrel and said second barrel, for absorbing at least part of an external force which is applied to said zoom lens 10 from the outside of said zoom lens, said external force being transmitted to said first barrel via said second barrel.

12. The zoom lens according to claim 1, wherein said zoom lens is incorporated in a digital camera.

15 13. A zoom lens comprising:

a plurality of lens groups which are moved with respect to each other to change a focal length of said zoom lens; and

20 a cam barrel having at least one cam groove formed on an inner peripheral surface thereof, wherein at least one of said plurality of lens groups is moved in a direction of an optical axis by rotation of said cam barrel in accordance with a contour of said cam groove,

25 wherein said cam barrel comprises: a first barrel having said cam groove on an inner peripheral surface

thereof; and a second barrel which is fitted on a front part of an outer peripheral surface of said first barrel, said first barrel and second barrel being movable in said optical axis direction with a predetermined clearance 5 therebetween in the optical axis direction while being rotatable together about said optical axis, so that an external force applied to said zoom lens from the outside of said zoom lens is transmitted to said first barrel via said second barrel,

10 wherein said zoom lens further comprises a spring disposed between said first barrel and said second barrel, and

wherein said spring biases said second barrel forward in said optical axis direction, and is compressed 15 when an external force is applied to said second barrel from the outside of said zoom lens in a direction to push said second barrel rearwards in said optical axis direction.

14. The zoom lens according to claim 13, wherein 20 said spring comprises a plurality of compression springs provided at substantially an equi-angular distance about an axis of said cam barrel.

15. The zoom lens according to claim 13, further comprising:

25 a stop formed on said outer peripheral surface of

said first barrel projecting radially outwards;

a linear guide barrel which guides said plurality of lens groups in said optical axis direction, and is positioned inside said first barrel to be rotatable about  
5 said optical axis direction relative to said first barrel and immovable in said optical axis direction relative to said first barrel; and

a flange ring fixed to the front end of said linear guide barrel,

10 wherein said second barrel is fitted on said outer peripheral surface of said first barrel between said flange ring and said stop to be movable in the optical axis direction by a predetermined amount of movement corresponding to said predetermined clearance, and is  
15 biased in a direction to be in press-contact with said flange ring by said spring.

16. The zoom lens according to claim 15, wherein said second barrel comprises a guide portion which is engaged with said stop to be slidable in said optical axis  
20 direction relative to said stop, said spring being disposed between said guide portion and said stop.

17. The zoom lens according to claim 13, further comprising:

a moveable external barrel positioned around said  
25 second barrel to be guided in the optical axis direction

without rotating about said optical axis;

an inward pin fixed to said moveable external barrel  
to project radially inwards; and

a guide groove formed on an outer peripheral surface  
5 of said second barrel, said inward pin being engaged with  
corresponding said guide groove so that said moveable  
external barrel moves in said optical axis direction via  
rotation of said second barrel.

18. The zoom lens according to claim 15, further  
10 comprising:

a moveable external barrel positioned around said  
second barrel to be guided in the optical axis direction  
without rotating about said optical axis;

an inward pin fixed to said moveable external barrel  
15 to project radially inwards; and

a guide groove formed on an outer peripheral surface  
of said second barrel, said inward pin being engaged with  
corresponding said guide groove so that said moveable  
external barrel moves in said optical axis direction by  
20 rotation of said second barrel,

wherein said flange ring comprises an outward  
projection which projects radially outwards, and

wherein said moveable external barrel comprises a  
linear guide groove which extends parallel to said optical  
axis, said outward projection being engaged with said  
25

linear guide groove to guide said moveable external barrel in said optical axis direction without rotating about said optical axis.

19. The zoom lens according to claim 13, wherein  
5 said first barrel comprises an annular raised portion formed on said outer peripheral surface of said first barrel in a vicinity of a front end portion of said first barrel to project radially outwards,

wherein a width of said annular raised portion in  
10 said optical axis direction is smaller than an axial length of said second barrel,

wherein an inner peripheral surface of said second barrel partly contacts said annular raised portion, and

15 wherein a slight gap is formed between said inner peripheral surface of said second barrel and said outer peripheral surface of said first barrel behind said annular raised portion with respect to the optical axis.

20. The zoom lens according to claim 19, further comprising:

20 a moveable external barrel positioned around said second barrel to be guided in the optical axis direction without rotating about said optical axis;

an inward pin fixed to said moveable external barrel to project radially inwards; and

25 a guide groove formed on an outer peripheral surface

of said second barrel, said inward pin being engaged with corresponding said guide groove so that said moveable external barrel moves in said optical axis direction via rotation of said second barrel,

5       wherein a position of said inward pin in said guide groove and a position where said inner peripheral surface of said second barrel contacts said annular raised portion do not overlap in said optical axis direction when said zoom lens is in operation.

10      21. The zoom lens according to claim 13, wherein said zoom lens is incorporated in a digital camera.

15      22. A zoom lens comprising:  
          a plurality of lens groups which are moved with respect to each other to change a focal length of said zoom lens;

          a movable hood barrel guided in a direction of an optical axis;

          an inward pin fixed to said movable hood barrel, said inward pin projecting radially inwards;

20      a cam barrel which is positioned inside said movable hood barrel to be rotatable about said optical axis; and  
          a guide groove formed on an outer peripheral surface of said cam barrel, said inward pin being engaged with said guide groove so that said movable hood barrel moves in said optical axis direction by rotation of said cam barrel,

wherein said guide groove comprises an assembling section and an operating section connected to said assembling section so as to extend along substantially a circumferential direction of said cam barrel,

5       wherein one end of said assembling section extends to the front end of said cam barrel so that said inward pin can be inserted into said guide groove from the front of said cam barrel via said assembling section, and

10      wherein said operating section comprises a zooming section in which rotation of said cam barrel causes said movable hood barrel to move forward and rearward in said optical axis direction.

23.     The zoom lens according to claim 22, further comprising a barrier block fixed to the front end of said movable hood barrel and having at least one barrier blade for opening and closing a photographic aperture of said zoom lens; wherein said rotation of said cam barrel causes said movable hood barrel to move forward and rearward in said optical axis direction to change a distance between a frontmost lens group of said plurality of lens groups and a barrier block in said optical axis direction.

24.     The zoom lens according to claim 22, further comprising:

25      a rotational position detector for detecting a rotational position of said cam barrel at least an

assembling position wherein said inward pin is positioned in said assembling section, and an operating position wherein said inward pin is positioned in said operating section, and

5           a controller which prohibits said cam barrel from rotating in said assembling position in a state where said inward pin is positioned in said operating section upon an assembly completion signal being input, and allows said cam barrel to rotate in said assembling position upon a  
10 disassembling signal being input.

25.   The zoom lens according to claim 22, further comprising another cam barrel, provided separately from said cam barrel, for moving said plurality of lens groups forward and rearward in said optical axis direction by  
15 rotation of said another cam barrel, said cam barrel and said another cam barrel rotating together about the optical axis.

26.   The zoom lens according to claim 23, further comprising a barrier drive ring for driving said at least  
20 one barrier blade of said barrier block to open and close said photographic aperture, wherein said barrier drive ring is driven to rotate about said optical axis by rotation of said cam barrel.

27.   The zoom lens according to claim 22, wherein  
25 said zoom lens incorporated in a digital camera.

28. A zoom lens comprising:

a plurality of lens groups which are moved with respect to each other to change a focal length of said zoom lens;

5 a zoom cam barrel having at least one cam groove on an inner peripheral surface thereof, at least one of said plurality of lens groups being moved in an optical axis direction by rotation of said zoom cam barrel in accordance with a contour of said cam groove;

10 a movable hood barrel for preventing unwanted light rays from being incident on said lens groups, said movable hood barrel being guided in said optical axis direction; and

15 a hood-driving cam barrel having a guide groove on an outer peripheral surface thereof, said movable hood barrel being moved in said optical axis direction by rotation of said hood-driving cam barrel in accordance with a contour of said guide groove,

wherein said hood-driving cam barrel is fitted on  
20 a front part of an outer peripheral surface of said zoom cam barrel to be rotatable about said optical axis together with said zoom cam barrel with a predetermined clearance provided between said zoom cam barrel and said hood-driving cam barrel in said optical axis direction.

25 29. The zoom lens according to claim 28, further

comprising a barrier block fixed to the front end of said movable lens hood and having at least one barrier blade for opening and closing a photographic aperture of said zoom lens.

5           30. A zoom lens comprising:

a plurality of lens groups which are moved with respect to each other to change a focal length of said zoom lens;

10          a focusing lens group positioned behind said plurality of lens groups and driven in said optical axis direction to bring an object to be photographed into focus;

15          a first cam barrel having at least one cam groove on an inner peripheral surface of said first cam barrel, at least one of said plurality of lens groups being moved in a direction of an optical axis by rotation of said first cam barrel in accordance with a contour of said cam groove;

20          a second cam barrel which is fitted on a front part of an outer peripheral surface of said first cam barrel to be rotatable about said optical axis together with said first cam barrel with a predetermined clearance provided between said first cam barrel and said second cam barrel in said optical axis direction;

25          a movable hood barrel positioned around said second cam barrel and guided in said optical axis direction;

              a barrier block fixed to the front end of said movable

hood barrel and having at least one barrier blade for opening and closing a photographic aperture of said zoom lens;

an inward pin fixed to said movable hood barrel to  
5 project radially inwards; and

a guide groove formed on an outer peripheral surface of said second cam barrel, said inward pin being engaged with said guide groove so that said movable hood barrel moves in said optical axis direction via rotation of said  
10 second cam barrel.

31. The zoom lens according to claim 30, further comprising a shock absorber, positioned between said first cam barrel and said second cam barrel, for absorbing at least part of an external force which is applied to said  
15 zoom lens from the outside of said zoom lens to be transmitted to said first cam barrel via said second cam barrel.